

7. Antarctic fur seal pup production in the South Shetland Islands; by Michael E. Goebel, Verónica I. Vallejos, Wayne Z. Trivelpiece, Rennie S. Holt and Jorge Acevedo.

7.1 Objectives: This section reports the results of a census of fur seal pups throughout the South Shetlands from 30 January – 5 February 2002. All sites reported to have pups in previous censuses (1986/87, 1991/92, and 1995/96) were visited. Two ice-free capes on the southern coast of King George Island (KGI) were also visited as well as Black Point on the north coast of Livingston Island. The two south coast sites of King George Island were chosen based upon an unpublished, anecdotal report that a number of fur seal pups were observed at Turret Point (KGI) during the 1999/00 austral summer. The two sites have suitable breeding habitat and were known to have substantial numbers of sub-adult and adult males hauling out. Currently all known fur seal colonies are on the northern coasts of the South Shetlands. Documenting colonization by breeding females on a south coast site would represent a major event in the history of recovery of this exploited population.

In addition, we compare the results of this survey with those from previous surveys conducted by the U.S. Antarctic Marine Living Resources Program in 1986/87, 1991/92, 1993/94, and 1995/96 and report on the rates of change in colony size between censuses.

7.2 Methods: The South Shetland Islands are situated south of the Drake Passage, 450 nautical miles southeast of Cape Horn off the northern flank of the Antarctic Peninsula, from which they are separated by the Bransfield Strait. They range from approximately 54.0°W to 63.0°W longitude and from 61.0°S to 63.5°S latitude (Figure 7.1).

Only pups were counted for this survey. Antarctic fur seal pups are born from late November to early January. Females arrive on shore approximately 1-2 days before giving birth. After tending to their pups for about a week they depart to sea to begin a series of foraging trips. Pups do not begin entering the water until a month old and then only in inter-tidal areas. They do not spend significant amounts of time in the water until they molt in mid-late February and do not depart natal rookeries until they are weaned in late-March and April. Juveniles and adults are continually arriving and departing and their presence onshore is influenced by numerous factors that cannot be controlled. Thus, fur seal pups represent the only portion of the population that can be reliably counted in its entirety. Pup production is, therefore, the best index of population size and trends in population numbers over time.

All previous censuses have reported a single count of pups for each site primarily because of the ease of counting relatively lower numbers of pups provided higher confidence in accuracy of the count. As the population has grown to thousands of individuals, variability in counts is now more likely. In order to provide confidence limits on pup production we had 3-4 individual counters at each site.

One day prior to the start of the census (29 January), the three primary counters censused an area (sub-colony) of Cape Shirreff approximately equal to the size of most South Shetland colonies. This count was done separate from the entire count of Cape Shirreff and was conducted to estimate intra-observer variability in counting. Each observer counted the area for live and dead pups three times. The colony was divided into three sections and each observer started their

counts in a different section. Pup mortality at the same area was monitored throughout the breeding season (18 November -10 January) by counting newly dead pups every day. Thus, a comparison of pup mortality measured by counting dead pups during the census with actual mortality throughout the breeding season was available.

In all colonies counting of both live and dead pups was by direct observation using hand held counters. At all sites, three to four observers counted pups. At one site, north San Telmo Island, the largest continuous breeding colony in the South Shetlands, instead of counting both live and dead pups, three counters counted live pups and one counter was solely dedicated to counting dead pups. Fur seal breeding areas in the South Shetlands are free of tussock grass or any vegetation, which can obscure pups. At each site the support vessel (R/V *Yuzhmorgeologiya*) would anchor or hove to offshore and a zodiac would be launched with a team of five to six people. Two people remained in the zodiac offshore of a colony while the other three to four were put ashore to count. While the counting crew was onshore, the zodiac surveyed beaches near colonies for any additional breeding groups. Landings were made at all but two sites, Fildes Peninsula and Cape Melville, King George Island. At both these sites no colonies had ever been reported but numerous adult and sub-adult males haul out; so surveys of extensive areas of the coastline were conducted by traveling approximately 15-30 meters from shore.

The census was conducted from 30 January-5 February 2002, well after the last pups are born (the last observed newborn pup at Cape Shirreff in 2001/02 was 10 January; U.S. AMLR unpublished data). Inclement weather can influence visibility and fur seal behavior, which in turn may influence variability in counts; thus, at each census location, weather, tide, and visibility were recorded.

7.3 Results: Measures of intra-observance variance from a selected area of Cape Shirreff are presented in Table 7.1. All counts were within 10% of individual means (max: 8.78%). Individual means were all within 3% of the grand mean.

Weather, visibility, and census conditions were generally excellent for the survey. Table 7.2 lists each site visited, latitude, longitude, date, census time, and weather conditions. Visibility at Cape Lindsey, Stinker Point, and Stigant Point was only fair due to fog. However, these conditions only affected finding the site and landing; once on shore, conditions did not affect counting of pups.

The distribution throughout the South Shetlands of colonies censused is shown in Figure 7.1. Total Antarctic fur seal pup production for the South Shetlands was $10,057 \pm 142$ (Table 7.3). Cape Shirreff, Livingston Island accounted for 64.2% (6,453 pups) of the total and San Telmo Islets off the northwest coast of Cape Shirreff accounted for an additional 21.1% (2,124 pups) of the total (Table 7.3, Figure 7.2). All other sites ($n=12$) had colonies of less than 500 pups (Table 7.3, Figure 7.2). Dead pups (138 ± 5.4) accounted for 1.4% of the total.

Only one site reported to have pups by previous survey teams was not visited. The site is one of three small islands in the Seal Island group and in previous surveys it has been called Saddle Rock due to its shape when viewed from a distance at sea. Saddle Rock also has a cave where previous census teams have found pups. For the purpose of calculating total pup production, the

count of pups at Saddle Rock was estimated at 63 pups (Table 7.3). The estimate is based upon an adjustment of the last count of Saddle Rock (101 pups in 1995/96) and applying the average rate of change at other sites in the Seal Islands between the 1995/96 census and the current census (Table 7.4).

Pup mortality at a selected site at Cape Shirreff (the same site censused for a calculation of intra-observer variance) recorded throughout the breeding period (~18 November-10 January) indicated a cumulative total of 52 dead pups (Figure 7.3). The mean for dead pups counted at the same site 19 days later was 12.7 (± 1.74).

7.4 Discussion: A comparison of this census with previous censuses revealed a net increase of 0.9% in pup production since the last census in 1995/96 (Table 7.4). The increase was not consistent with all colonies. The greatest rates of increase (averaged annual) were at Cape Shirreff (5%) and Start Point, Livingston Island (2.7%). Cape Valentine, Elephant Island had a slight increase (0.3%), while Stigant Point, KGI showed no change. Seal Islands, Cape Lindsey, Elephant Island, Window Island, and San Telmo Island showed net decreases. The largest per capita decrease was at San Telmo Island (-3.5%) and Cape Lindsey had the largest percentage decrease (-9.4%).

The average annual rate of increase for all colonies combined from 1986/87 to 1991/92 was 13.5% (Table 7.4, Figure 7.4). From 1991/92 to 1993/94 the rate of increase remained similarly high at 13.9%. For the next two years, the averaged annual rate of increase declined to 8.5%, and for the last six years (1995/96-2001/02), the rate declined even further to 0.9%.

The fact that rates of change at individual colonies were not similar across the archipelago suggests that the differences are, at least in part, the result of local phenomena and not a regional-scale cause. The differences in the averaged annual rate of change were also large enough not to be associated with counting variance. It is particularly interesting that, at the two sites where there are "mainland" colonies and offshore island colonies, that the offshore islands (Window Island and San Telmo Island) showed decreases and the "mainland" colonies (Start Pt. and Cape Shirreff) had increases. At both these sites, the offshore island colonies are less than a kilometer away from "mainland" colonies, thus offshore resources for foraging and rearing young can effectively be considered the same for both populations (e.g. Cape Shirreff and San Telmo). This would suggest that any changes might be due to differences in the on-land habitat for breeding (e.g. colony density). For a species that lives ca. 20 years, in a rapid re-colonizing phase of growth (e.g. fur seals from 1980-1990s), the habitat available for a particular strong cohort recruited in to the adult breeding population early in a re-colonizing phase, is very different than that available in the current population. That is to say, San Telmo or Window Island may have been the best available site for breeding 15 years ago, but an immigrant from a more recent cohort may have more options as to where to breed. Large, low-density habitats more recently colonized may be a more favorable choice of where to breed.

Most colonies of fur seals in the South Shetlands are small (<500 pups) and confined to small islands off the coasts of larger islands such as Elephant and Livingston Islands. The available breeding habitat on these smaller offshore islands is extremely limited and most of these colonies are limited in their capacity to support much larger populations of fur seals. Large ice-free capes

and islands such as Cape Shirreff, Byers Peninsula, Desolation Island, Rugged Island and those of the southern coasts of the South Shetlands are likely locations for future growth of fur seal populations. Of these, only Cape Shirreff and Byers Peninsula have been colonized. The population at Start Point (Byers Peninsula) is still rather small (150 pups) and though Cape Shirreff currently has a pup production in excess of 6,000 pups it still has large areas that have not been re-colonized.

Our sample measures for intra-observer variance were low and demonstrate the ease of counting pups by direct observation in the South Shetlands, where breeding and pup rearing habitat is generally open and free of tussock grass (*Poa flabellate*). Tussock grass is common at lower latitude breeding sites of this species especially South Georgia where the center of the population breeds. At lower latitude colonies, the presence of tussock grass is likely one of the greatest sources of error in estimations of pup production.

The greatest source for error in pup production estimates in the South Shetlands are likely due to the timing of the census and to accurately estimating pup mortality. Timing of the census is critical since pups range further as they get older, and once pups molt (in late February) they begin spending increasing portions of their time in the water. Ideally pup counts should be conducted within several weeks of the termination of pupping. Tradeoffs exist, however, since the earlier the census is conducted, the more likely counters will encounter aggressive animals that prevent enumerating sections of a colony or, at the very least, aggressive behavior towards counters causes inaccuracies in counts. Once pups begin to molt into adult pelage (approximately ten weeks old) they are much more mobile and spend more time swimming offshore of colonies making it difficult to make an accurate census. This census began 20 days after the last pups were born at Cape Shirreff and before the median age of pups was eight weeks. The median date of pupping at Cape Shirreff in 2001/02 was 7 December (Goebel *et al.*, 2002). Assuming that other colonies in the South Shetlands had a similar distribution and median date of pupping, the median age of pups would thus have been between 55-61 days (or ~8 weeks) at the time of the census. Thus, the timing of our census minimized errors associated with seasonal changes in the distribution of animals.

Pup mortality and the error associated with it for censusing colonies are less tractable than pup behavior and timing of the census. In this study, we demonstrated that a single dead pup count at the time of a colony survey leads to an underestimate of pup mortality and total pups born. For example, when dead pups were counted daily at our sample colony, the cumulative mortality by the end of the pupping period was 52 pups. When we censused the same area 19 days later, the mean number of dead pups counted by three observers was 13. Counting the number of dead pups visible in late January/early February at our sample colony underestimated pup mortality by 75%. If we assume a similar rate of underestimating for all colonies, our mean total dead pup count of 138 would represent an actual on land mortality of 552 pups. Thus, our estimate of 10,057 (± 141) can be considered a minimum number of pups born.

There is, however, yet another significant source of pup mortality that was not measured in this study. Our study only measured *on land* mortality. Leopard seal predation on fur seal pups, once they begin entering the water at approximately one month old, represents a significant source of mortality that is not possible to estimate by single visits to colonies to count pups. It

has, however, been documented and measured at Seal Island, one of the colonies in the Elephant Island group (Boveng *et al.*, 1998). In that study, which took place from 1986-1995, leopard seal mortality was calculated to range from 32-69% of total pups born. They hypothesized that leopard seal predation may be regulating recruitment and preventing recovery of fur seals to pre-exploitation (i.e. pre-1820's) levels (Boveng *et al.*, 1998). They provided three conceptual models of leopard seal predation that described the impact of predation given various criteria and assumptions. One of their models describes predation mortality as density dependent at low densities of prey (i.e. fur seals) and inversely density dependent at moderate to high densities, producing a stable, low-density equilibrium or "predator pit" that prevented further recovery. The North Cove colony, however, was not at equilibrium as the number of pups declined from 239 to 197 pups born during the years that they quantified predation. Our census of North Cove revealed that the decline that they documented has continued since only 15 pups were counted. Two of the counters in our team had had previous experience working with the Seal Island population and noted that the densities of adult animals on shore at north cove indicated that much of the decline was likely due to an increase in predation. This observation was further supported by the fact that two other colonies at Seal Island, North Annex and "Big Boote" had substantial increases in pup production (16.7% and 84%, respectively, since the 1994/95 census; Boveng *et al.*, 1998). The total number and presence of leopard seals does fluctuate both within a season and between seasons (Boveng *et al.*, 1998; Hiruki *et al.*, 1999) but during the years that they studied predation, the impact of predation was never what appears to have occurred at North Cove during the 2001/02.

The North Cove colony at Seal Island is unique in that the colony has an extensive deep but calm pool that is protected from surf that fur seal pups have access to at an earlier age than at other sites. It also has a channel relatively protected from surges and surf that allows leopard seals, at all but the lowest tides, access to pups at a younger age (at least compared to other sites). Thus, fur seal pups at this site may be more vulnerable to leopard seal predation. Whether predation at other sites is only delayed, or delayed but mitigated by older pups being less naïve, is not known and was not addressed in their study. Top-down regulation of marine mammal populations has been recorded in other ecosystems. Estes *et al.*, (1998) provided evidence that Orca whale predation was responsible for recent declines in sea otter populations in the Aleutian Islands. They also showed with modeling of predator/prey numbers and energetic considerations of the predator that surprisingly few individual predators could account for significant declines. Leopard seals, preying on juveniles instead of all age classes (as is the case with sea otter/killer whale), may nonetheless, be responsible for limiting recovery of fur seal populations by limiting recruitment. This possibility warrants further study, particularly if leopard seal populations have increased or are increasing in the Antarctic Peninsula region.

7.5 Acknowledgements: The R/V *Yuzhmorgeologiya*, her officers and crew, provided invaluable support to the census team. The authors wish to thank, in particular, Captain Nikolay Boykov, Chief Mate Aleksey Burdun; also Roger Hewitt and Adam Jenkins, who provided zodiac support to the census team. The San Telmo Islets and Cape Shirreff required additional counters and we wish to thank Romeo Vargas, Juan Pablo Torres and John Lyons for their enthusiastic support.

7.6 References:

Aguayo L., A. 1978. The present status of the Antarctic fur seal *Arctocephalus gazella* at South Shetland Islands. *Polar Record* 19(119): 167-176.

Aguayo L., A. and D. Torres N. 1967. Observaciones sobre mamíferos marinos durante la vigesima comisión Antártica Chilena. Primer censo de pinípedos en las Islas Shetland del Sur. *Rev. Biol. Mar.* 13(1): 1-57.

Bengtson, J.L., Ferm, L.M., Härkönen, T.J., and Stewart, B.S. 1990. Abundance of Antarctic fur seals in the South Shetland Islands, Antarctica, during the 1986/87 austral summer. In: K.R. Kerry and G. Hempel (eds.). *Antarctic Ecosystems: Ecological Change and Conservation. The fifth symposium of Antarctic biology. Scientific Committee on Antarctic Research (SCAR)* Springer-Verlag, Berlin. Pp. 265-270.

Boveng, P.L., Hiruki, L.M., Schwartz, M.K., and Bengtson J.L. 1998. Population growth of Antarctic fur seals: Limitation by a top predator, the leopard seal? *Ecology* 79(8): 2863-2877.

Bruce, W.S. 1920. Appendix II. Note of Dr. Bruce's remarks at the discussion of his letter of the 14th May, 1918. Report of the Interdepartmental committee on research and development in the dependencies of the Falkland Islands. London, H.M. Stationery off. [printed by J.J. Keliher & co., ltd.] 1920. 164 p.

Campbell, R.J. 2000. The discovery of the South Shetland Islands: the voyages of the Brig Williams 1819-1820 as recorded in contemporary documents and the journal of midshipman C.W. Poynter. R.J. Campbell (ed.). London: Hakluyt Society, 232 p. Series title: Works issued by the Hakluyt Society ; 3rd ser., no. 4.

Clark, A.H. 1887. The Antarctic fur-seal and sea-elephant industry. The fisheries and fishery industries of the United States. Prepared through the co-operation of the commissioner of fisheries and the superintendent of the tenth census by George Brown Goode. Sect. 5: History and methods of fisheries, vol. 2, pp. 400-467. Washington, Govt. Print. Off., 1884-87.

Croll, D.A., Bengtson, J.L., Holt, R., and D. Torres-N. 1992. Census of Antarctic fur seal colonies of the South Shetland Islands, 1991/92. In: J. Rosenberg and R. Hewitt (eds). *AMLR 1991/92 Field Season Report. Administrative Report LJ-92-17. Southwest Fisheries Science Center, NOAA/NMFS, La Jolla, CA 92037.*

Estes, J.A., Tinker, M.T., Williams, T.M., and Doak, D.F. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. *Science* 282(5388): 473-476.

Hiruki, L.M., Schwartz, M.K., and Boveng, P.L. 1999. Hunting and social behaviour of leopard seals (*Hydrurga leptonyx*) at Seal Island, South Shetland Islands, Antarctica. *Journal of Zoology* (Lond.) 249(1): 97-109.

Hunt, J.F. 1973. Observation on the seals of the Elephant Island, South Shetland Islands, 1970-71. *British Antarctic Survey Bulletin* 36: 99-104.

Kellogg, R. 1943. Past and present status of marine mammals of South America and the West Indies. The Smithsonian Report for 1942. pp 299-316. Publication 3719, U.S. Government Printing Office, Washington, D.C. 1943.

Meyer, W.M., Walker, B.G., and Holt, R.S. 1996. Antarctic fur seal abundance and distribution in the South Shetland Islands, 1996. In: J. Martin (ed). AMLR 1995/96 Field Season Report. Administrative Report LJ-96-15. Southwest Fisheries Science Center, NOAA/NMFS, La Jolla, CA 92037.

O'Gorman, F.A. 1961. Fur seals breeding in the Falkland Islands dependencies. *Nature* 192: 914-916.

Roberts, B. 1960. Chronological list of Antarctic expeditions. *Polar Record* 9: 97-134, 191-239.

Weddell, J. 1827. A voyage towards the South Pole: performed in the years 1822-24, containing an examination of the Antarctic Sea. (1827). A reprint with a new introd. by Vivian Fuchs [Annapolis, Md.] United States Naval Institute [1970]. 324 p.

Table 7.1. Results of a pre-census count of pups at a selected site at Cape Shirreff, Livingston Island providing an example of intra-observer variance in counting.

Count	Observer:								
	1			2			3		
	Live	Dead	Total	Live	Dead	Total	Live	Dead	Total
1	591	15	606	541	6	547	587	12	599
2	595	20	615	631	7	638	622	10	632
3	618	20	638	606	8	614	619	13	632
Mean:	620			600			621		
S.E.:	9.53			27.23			11.00		
Max. difference from mean:	2.96%			8.78%			3.54%		
Difference from grand mean:	1.01%			2.25%			1.23%		

Table 7.2. South Shetland Islands Antarctic fur seal pup census sites, locations, dates of census and weather at the start of each site census. Time represents the duration of the census in decimal hours.

# Site Name	Lat	Long	Date	Census Start	Time (h)	Wind Direction	Wind Speed (km/h)	Air Temp. (°C)	Air Pressure (mm)	RH	PAR ¹ Light	Visibility	Tide
Smith Island													
1 Cape Smith, Smith I.	-62.884	-62.284	31-Jan-02	03:30	1.55	44	4.0	2.5	1003	88	3	Exc	Low
Livingston Island Sites:													
2 San Telmo Islands	-62.468	-60.742	30-Jan-02	09:00	2.85	247	9.3	2.7	998	93	481	Exc	Low
3 Window Island	-62.577	-61.117	30-Jan-02	14:30	4.38	274	14.1	2.7	999	100	657	Exc	Low
4 Start Point	-62.577	-61.117	30-Jan-02	14:30	3.08	251	13.5	2.6	1000	100	345	Exc	Low
5 Desolation Island	-62.438	-60.314	31-Jan-02	11:50	1.27	235	4.7	2.7	1005	88	621	Exc	High
King George Island Sites:													
6 Fildes Peninsula	-62.196	-59.108	31-Jan-02	17:00	2.15	78	1.5	2.7	1006	92	328	Good	High
7 Stigant Point	-62.005	-58.858	1-Feb-02	04:16	2.28	56	13.4	1.7	1005	102	1	Fair	Med
8 Turret Point	-62.103	-57.895	4-Feb-02	07:15	1.88	275	14.7	4.0	995	93	156	Exc	High
9 Cape Melville	-62.043	-57.564	4-Feb-02	12:05	1.20	259	8.5	4.1	994	92	1186	Exc	High
Elephant Island Sites:													
10 Stinker Point	-61.270	-55.374	2-Feb-02	06:40	1.52	307	12.0	2.1	995	109	98	Fair	High
11 Cape Lindsey	-61.133	-55.529	2-Feb-02	09:35	4.25	308	13.6	2.6	995	109	428	Fair	High
12 Seal Island, Day 2	-60.991	-55.342	3-Feb-02	17:50	3.08	330	7.0	2.3	999	107	285	Good	High
13 Seal Island, Day 1	-60.989	-55.345	2-Feb-02	17:50	2.63	280	13.4	2.7	997	107	176	Good	Med
14 Cape Valentine	-61.127	-54.633	3-Feb-02	15:00	3.33	253	11.7	3.4	996	100	871	Exc	Low

¹ Photosynthetically available radius (PAR), a measure of light level.

Table 7.3. Pup production at Antarctic fur seal colonies in the South Shetland Islands, 2001/02. Sites are grouped by geographic proximity and by longitude (west to east). Each census was conducted with three to four counters from 30 January – 5 February 2002 and is presented with mean standard error (SE) and 95% confidence interval. ("n/c" indicates "not counted".)

Site Name	n ^a	LIVE			DEAD			TOTAL			% SSI ^b	
		Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI	Total	Total
Smith Island												
Cape Smith, Smith I.	4	7	0.00	-	0	-	-	7	0.00	-	0.07	
Livingston Island Sites:												
Start Point	4	150	4.36	8.54	0	0.25	0.49	150	5.22	9.03	1.49	
Window Island	4	393	13.54	26.54	5	0.91	1.79	398	16.83	27.95	3.95	
San Telmo Islands:												
North San Telmo	3	1307	130.44	255.65	40 ^c	-	-	1347	130.44	255.65	13.39	
South San Telmo	3	774	15.53	30.45	3	0.33	0.65	777	15.77	30.91	7.73	
San Telmo Islands, TOTAL		2081	144.06	282.35	43	0.33	0.65	2124	144.16	282.55	21.12	
Cape Shirreff	3	6372	46.61	91.35	81	5.70	11.16	6453	40.92	80.21	64.17	
Black Point	3	3	-	-	1	-	-	4	-	-	0.04	
Desolation Island	4	2	0.00	-	0	-	-	2	0.00	-	0.02	
King George Island Sites:												
Fildes Peninsula	Z	0	-	-	n/c	n/c	n/c	0	-	-	0.00	
Stigant Point	4	158	11.37	22.28	0	-	-	158	8.50	22.28	1.57	
Turret Point	4	0	-	-	0	-	-	0	-	-	0.00	
Cape Melville	Z	0	-	-	n/c	n/c	n/c	0	-	-	0.00	
Elephant Island Sites:												
Seal Islands:												
Seal I., Site 1 ("North Cove")	4	15	0.25	0.49	0	-	-	15	0.29	0.49	0.15	
Seal I., Site 2 ("North Annex")	4	94	4.65	9.11	2	0.00	-	96	4.16	9.11	0.95	
Seal I., Site 3 ("Big Boote")	3	66	0.00	-	0	-	-	66	0.00	-	0.66	
"Large Leap" Island	3	190	11.24	22.03	2	0.00	-	192	11.24	22.03	1.91	
"Saddle Rock" Island	-	n/c (63) ^d	-	-	n/c	n/c	n/c	63 ^c	-	-	0.62	
Seal Islands, TOTAL		427	7.95	15.59	4	0.00	-	431	7.95	15.59	4.29	
Cape Lindsey	3	141	0.33	0.57	1	0.00	-	142	0.58	0.57	1.41	
Stinker Point	Z	0	-	-	0	-	-	0	-	-	0.00	
Cape Valentine	4	186	4.18	6.06	2	0.00	-	188	3.09	6.06	1.87	
Total South Shetland Islands		9919	154.24	302.31	138	5.36	10.51	10057	141.83	240.74	100.00	

^a The number of observers (counters) at each site. "Z" indicates a zodiac survey of the shoreline, conducted at sites where there were no known colonies.

^b Percent of the total South Shetland Islands pup production.

^c Single dedicated count by one counter. (At San Telmo North three people counted live and one person counted dead pups. All other sites each counter counted both live and dead pups.)

^d Sea conditions prevented landing at "Saddle Rock" I. The value presented is an estimate based on a February 1996 census using average rate of decline of other Seal I. sites.

Table 7.4. A comparison of pup production numbers at Antarctic fur seal colonies in the South Shetland Islands over a 15-year period from 1986/87-2001/02. Percent annual rate of change between censuses is calculated. Values are for total pups counted (live and dead).

Site	1986/87 ^a	1991/92 ^b	Annual rate of change [%]	1993/94 ^c	Annual rate of change [%]	1995/96 ^c	Annual rate of change [%]	2001/02 ^d	Annual rate of change [%]
Cape Shirreff, Livingston I.	718	2583	51.9	3474	17.2	4968	21.5	6453	5.0
San Telmo Islands	1875	2340	5.0	2973	13.5	2684	-4.9	2124	-3.5
Window Island	297	375	5.3	397 ^e	2.9	418	2.7	398	-0.8
Start Point, Livingston I.	0	43	-	86 ^e	50.0	129	25.0	150	2.7
Desolation Island	1	0	-	n/c	-	1	-	2	-
Stigant Pt., King George I.	157	134	-2.9	146 ^e	4.5	158	4.1	158	0.0
Cape Valentine, Elephant I.	45	126	36.0	124	-0.8	185	24.6	188	0.3
Cape Lindsey, Elephant I.	203	227	2.4	296	15.2	325	4.9	142	-9.4
Seal Islands:									
Seal Island (all sites)	249	305	4.5	299	-1.0	283	-2.7	176	-6.3
"Large Leap" Island	275	258	-1.2	306	9.3	292	-2.3	181	-6.4
"Saddle" Rock & Cave	n/c	n/c	-	63	-	101	30.2	63 ^e	-6.3
TOTAL	3820	6391	13.5	8164	13.9	9544	8.5	10035	0.9

^a Source: Bengtson, J.L., L.M. Ferm, T.J. Härkönen, and B.S. Stewart. 1990. Abundance of Antarctic fur seals in the South Shetlands, Antarctica, during the 1986/87 austral summer. In: K.R. Kerry, G. Hempel, (eds). Antarctic Ecosystems: Ecological Change and Conservation. Springer-Verlag, Berlin. Pp. 265-270.

^b Source: Croll, D.A., J.L. Bengtson, R. Holt, and D. Torres-N. 1992. Census of Antarctic fur seal colonies of the South Shetland Islands, 1991/92. In: J. Rosenberg and R. Hewitt (eds). AMLR 1991/92 Field Season Report. Administrative Report LJ-92-17. Southwest Fisheries Science Center, NOAA/NMFS, La Jolla, CA 92037.

^c Source: Meyer, W.M., B.G. Walker, and R.S. Holt. 1996. Antarctic fur seal abundance and distribution in the South Shetland Islands, 1996. In: J. Martin (ed). AMLR 1995/96 Field Season Report. Administrative Report LJ-96-15. Southwest Fisheries Science Center, NOAA/NMFS, La Jolla, CA 92037.

^d Mean values are reported for 2001/02: see table 7.2.

^e Estimated values. 1993/94 estimates for Window I., Start Pt., and Stigant Pt. are based upon censuses before and after and assuming a constant rate of change. "Saddle Rock" and Cave estimate in 2001/02 is based upon the 1995/96 census and applying the average rate of change at other Seal Island sites that were counted.

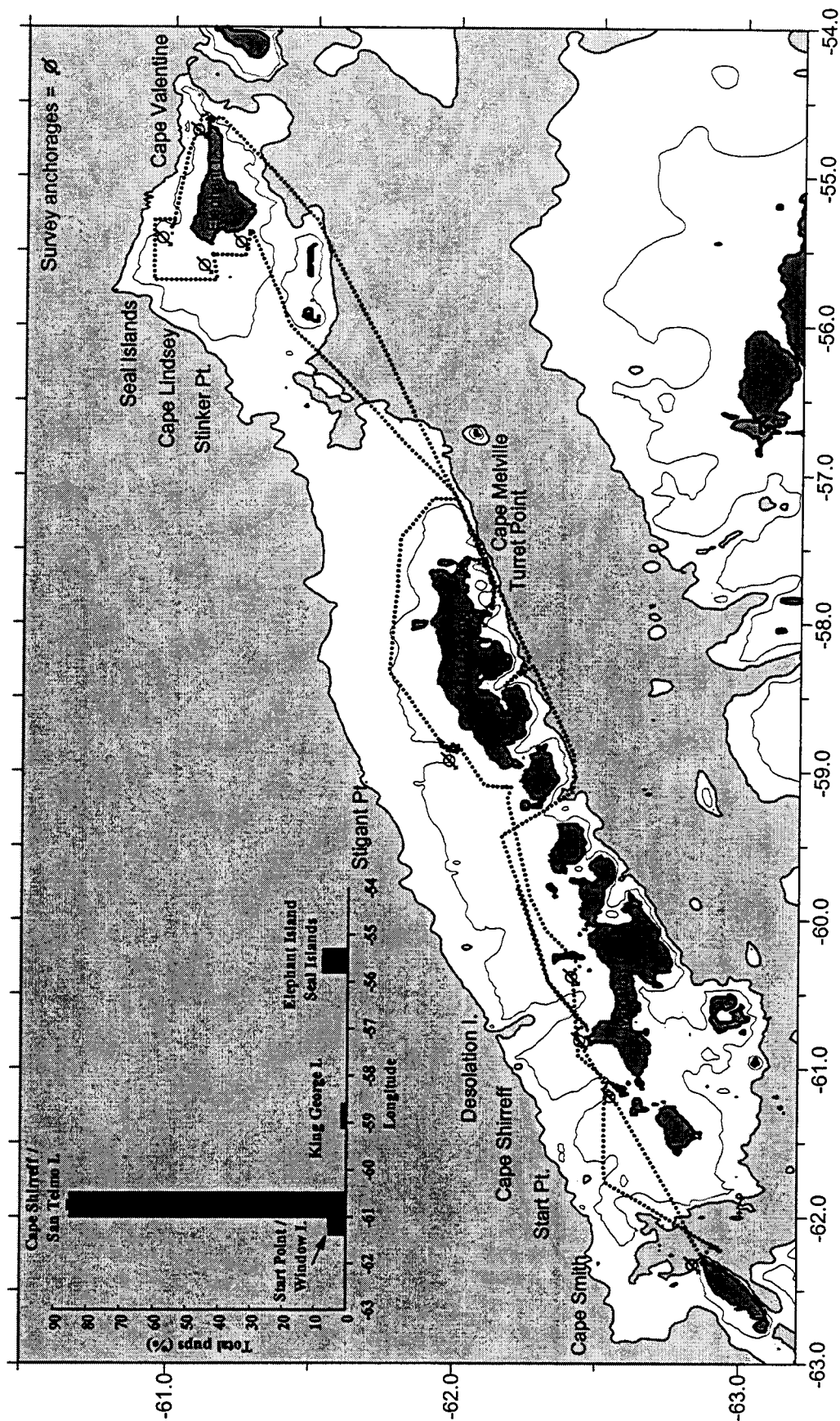


Figure 7.1. The study area, the South Shetland Islands, from Smith Island to Elephant Island. Islands are shown in dark gray, the continental shelf (to the 500m shelf break) is shown as white with a 250m contour line and a heavier line at 500m depth delineating the shelf edge. The survey ship's trackline is plotted as a dotted line. Anchorages (or sites where the ship hove to) are symbol labeled and an associated site name corresponding to each anchorage is printed just off the continental shelf from each site. The inset plot shows the percent total pup production by longitude for the entire archipelago.

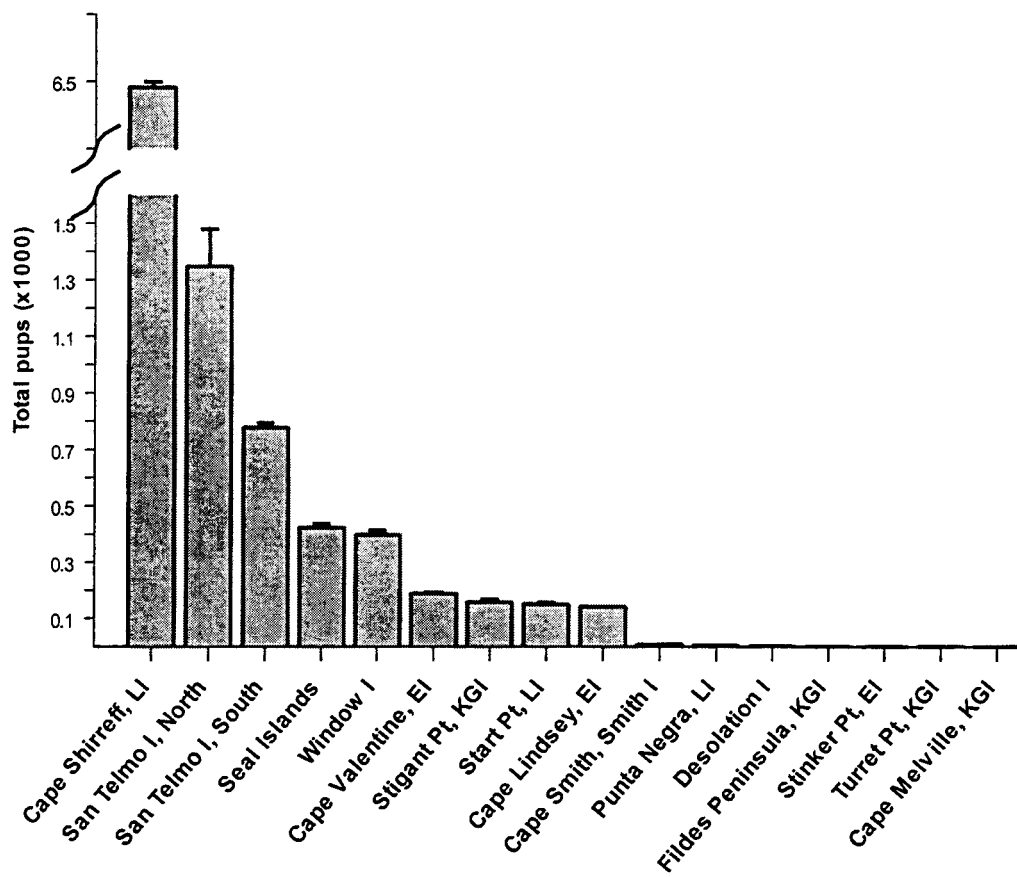


Figure 7.2. Total pup production by site in decreasing order of total pups born.

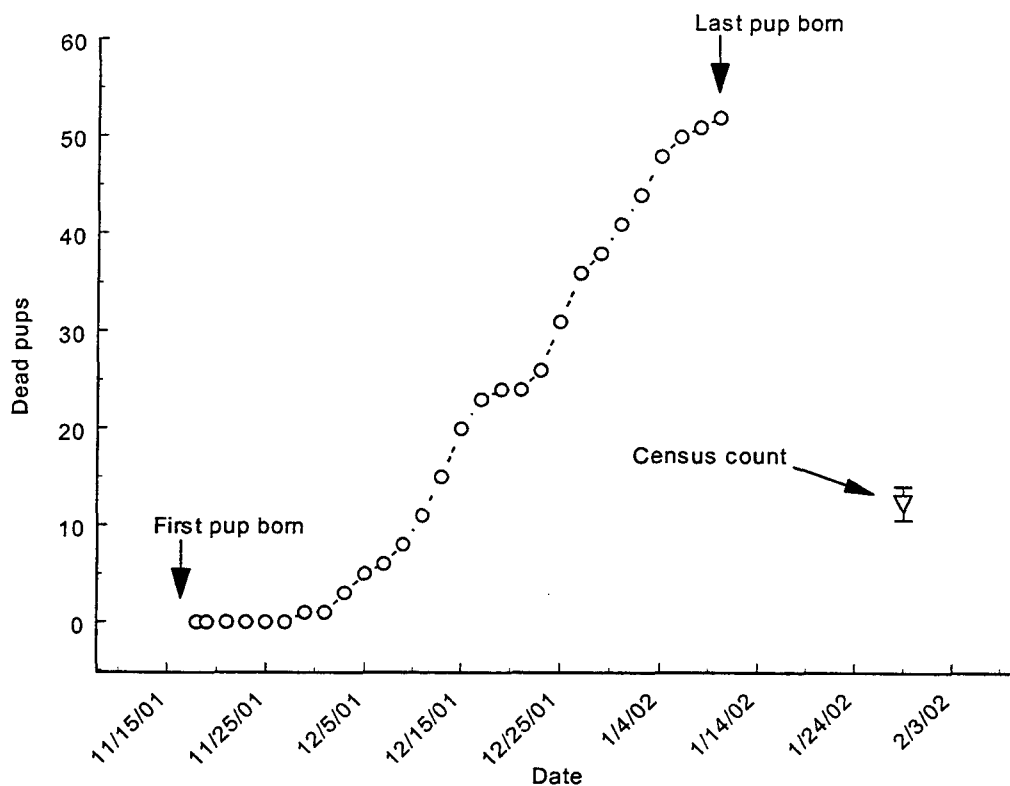


Figure 7.3. Cumulative pup mortality through the pupping period (18 November – 10 January) at a site on Cape Shirreff that accounted for approximately 10% of total pup production at Cape Shirreff. Live and dead pups were counted at this site around the start of the census (29 January) to estimate intra-observer variance. The mean number of dead pups counted on 29 January is plotted with standard error bars for comparison to total dead pups counted during the breeding season.

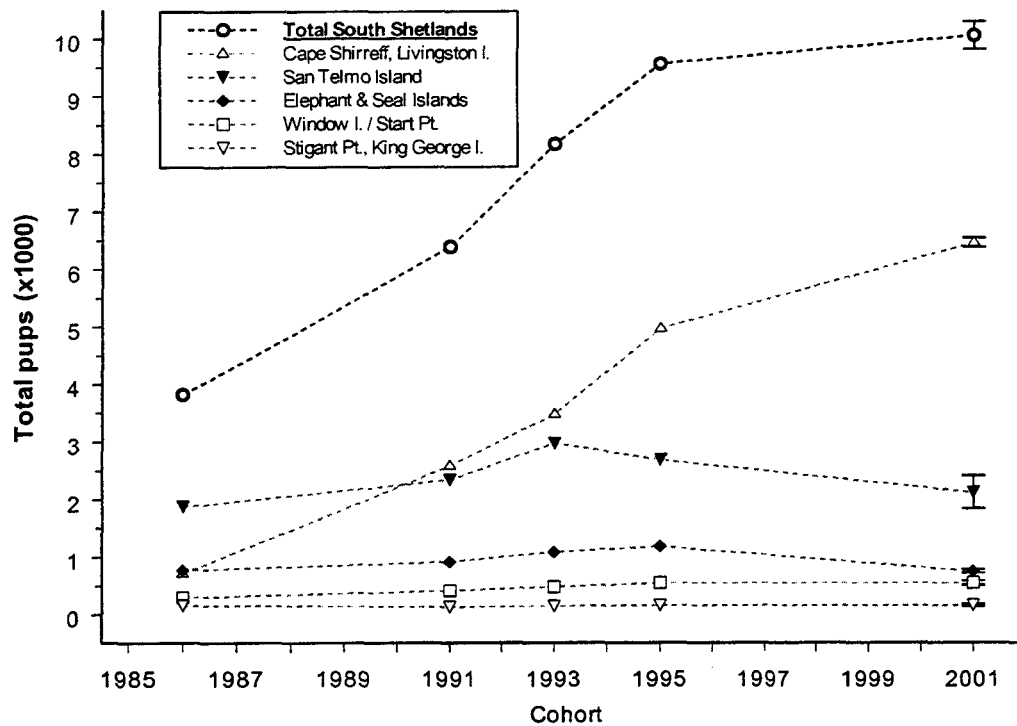


Figure 7.4. Total pup production over time from the 1986 cohort to the current census showing changes in the rate of pup production between censuses. The average annual rate of increase for fur seals in the South Shetlands has diminished to 0.9% per year since the 1995/96 census. This is down from ~13% per year up until 1993/94 and 8.5% from 1993/94 to 1995/96.